10/524137

DT05 Rec'd PCT/PTO 11 FEB 2005

BIODEGRADABLE FIBROUS SUPPORT FOR SOIL MULCHING

The invention relates to a biodegradable fibrous support for soil mulching, which can be used especially in the field of horticulture, market gardening, landscaping (tree nursery, green spaces).

In the rest of the description, the expression "fibrous support" denotes a support based on coniferous or deciduous unbleached or bleached plant fibres, or fibres of annual plants such as cotton, ramie, jute, flax, hemp etc., or synthetic fibres such as e.g. viscose, these fibres being biodegradable and they can be used by themselves or as a mixture, said support being furthermore able to comprise additives, in a manner that is not exhaustive, such as carbon black, hydrophobic resins (epichlorhydrin, polyamide etc.), fungicide, fungistatic and bactericidal agents, the mass of the support being between 40 g/m^2 and 200 g/m^2, advantageously 150 g/m^2.

The materials for mulching of the soil have to solve a certain number of the following objectives: prevent the weeds from growing shoots, maintain the structure of the soil, control the variations of the climate (moisture, temperature), assure a regular production both quantitatively and qualitatively, and make possible their mechanical application on the ground.

Several types of soil mulching materials are nowadays proposed, among which the plastic films and papers and nonwovens can be distinguished.

Firstly, black plastic sheeting is known, which has the advantage of being solid, despite its low weight per unit area, and thus being weather-resistant. However, this plastic sheeting has a certain number of drawbacks, especially that of not being biodegradable, its lifetime being in the order of 450 - 600 years. For obvious environmental reasons, plastic cannot be buried in the soil. Consequently, when the harvesting has been completed and the grower wishes to plough his land, he must completely remove the plastic. The cost of this operation is estimated to be 20% of the total cost of the mulching.

Moreover, since the plastic heats up very quickly when exposed to solar rays, the leaves of the plant close to the ground adhere and then burn having as consequences, firstly, the decrease of the productivity because of delayed growth and, secondly, they can only be removed with removal of this film. It is estimated that the removal of one ton of plastic entails the removal of one ton of plants and earth that have remained attached to the said plastic. Consequently, the plastic is virtually unrecyclable, the cost of washing it being unacceptably high for such an operation.

To solve the problem related to biodegradability, attempts have been made to manufacture films based on biodegradable materials, such as polymers of polylactic acid (PLA). In this sense, the document FR-A-2 733 520 describes association of a net or a "spunbund" of PLA with a film based on BAPE (biodegradable aliphatic polymer), i.e. a material from fossil resources (oil or gas) by heat sealing. However, this type of product has the inconvenience of being expensive to produce. Moreover, and above all, the fossil resources last for a limited period and, at least as far as oil is concerned, its reserve is estimated to last about forty years (source BP). Accordingly, the use of these materials for mulching of the soil is eventually compromised.

The document EP-A-637 641 describes, still concerning mulching, a non-woven composed of filaments produced entirely of a polymer or a polymer mixture derived from lactic acid. One of the main disadvantages of this kind of a product is its cost.

The mulching papers have inverse properties i.e. their degradability is fast, but on the other hand, their mechanical characteristics, especially their tearing strength, are low compared with plastics.

To solve this problem, the document FR-A-2 016 071 describes mulching papers treated with urea-formaldehyde resins. However, despite this treatment, the paper can break due to the effect of the watering phases, which expand the paper, and of the drying phases which retighten the paper.

The document WO 01/25536 of the Applicant describes a mulching paper comprising a resin based on epichlorhydrin, the paper being degraded by spraying an enzymatic solution capable of destroying both the resin and the cellulose. However, the described papers are adapted to short growing periods e.g. of the lettuce type. In particular, the mentioned paper based on deciduous fibres (20 %), coniferous fibres (50 %) and epichlorhydrin resin (3 %), sold by the Applicant under the trademark SEQUANA®, has a satisfactory strength during 3 - 4 months only, thus preventing its use for longer growing periods of e.g. 4 – 5 months with regard to melons, 9 months for the strawberries, 2 – 4 years in the field of tree nursery and green spaces.

The document JP2222421 describes a biodegradable mulching paper composed of a support based on plant fibres coated with an emulsion comprising as main constituent a copolymer of polyhydroxybutyrate acid (PHB) and polyhydroxyvalerianic acid (PHV) as a mixture with a natural polymer of starch and cellulose type and a synthetic polymer such as polylactic acid. No information is given regarding lifetime of this kind of a support. And once again we are confronted with the problem related to cost reasons.

In other words, the problem that the invention aims to solve is that of developing a mulching support based on plant fibres, which would be inexpensive, resistant during the relatively long-term growing, in practice in the order of 1 – 36 months and 100 % biodegradable within a time limit as short as possible after said growing has ended and at a low cost.

To do this, the invention proposes a biodegradable fibrous support for mulching of the soil, characterized in that it further contains biodegradable thermobonding fibres distributed in the mass.

In the rest of the description and in the claims, the expression “thermobonding fibres” denotes short fibres having a size of between 1 and 30 mm, preferably in the order of 5 mm, the average melting point of which is between 60°C and 180°C, these fibres being able to melt during the manufacturing process of the support so as to bind the fibres nearby and to strengthen the mechanical properties of the said support. In

practice, the fibres are chosen so that they melt at the temperature, at which the support is manufactured, which is about 100°C if the support is manufactured on a paper machine and about 170°C if the support is manufactured on a non-woven machine.

The thermobonding fibres of the invention may have a unique or double melting point on the assumption that the fibre is in the form of a so-called "bicomponent" fibre, corresponding to a fibre comprising two polymers having distinct physical and/or chemical characteristics, extruded from the same die for forming a single filament. In other words, the fibre in is the form of a core, having a first melting point surrounded by a sheath having a second lower melting point. This is e.g. the case with PLA-fibres sold by UNITIKA under the trademark TERRAMAC®, especially under the reference PL80, the core and sheath melting points of which are equal to 170°C and 130°C, respectively.

In an advantageous embodiment, the thermobonding fibres therefore consist exclusively of polylactic acid fibres such as e.g. the above-mentioned.

In other words, the invention consists in incorporating thermobonding fibres into the fibrous support, which allows to reinforce the mechanical strength of the support during the whole growing period, yet without delaying the degradation process of the plant fibres, which is faster than that of the material making up the thermobonding fibres.

In practice, the thermobonding fibres represent between 5 and 50% by weight, advantageously between 10 and 15% by weight of the support. For a concentration of less than 5%, there aren't enough fibres to reinforce efficiently the mechanical characteristics of the support. For a concentration more than 50%, the support is economically less interesting.

In a particular embodiment, to reinforce the fibrous support, said support is provided with a grid, which is either maintained on the whole or part of at least one face of the support, or incorporated into the whole or part of the mass of the support.

In the rest of the description and in the claims, the expression "grid" denotes a grid formed by a network of crossed non-woven threads comprising at least two webs of warp and weft threads, these warp and weft threads being interconnected at their crossings by a bonding agent creating a series of gluing points. This type of a grid and its manufacturing process are described more precisely e.g. in the document EP-A-1 111 114.

In practice, the grid is produced of biodegradable polymers chosen from the group comprising polylactic acid, polycaprolactone, viscose, modified viscose such as of the LYOCELL or MODAL type, polyhydroxybutyrate and polyhydroxyalcanoate, by themselves or as a mixture. In an advantageous embodiment, the grid is produced exclusively of modified viscose threads and corresponds e.g. to the grid sold by CHAVANOZ INDUSTRIE under the reference 4032/71. According to another embodiment, the grid is produced solely from polylactic acid fibres such as those sold e.g. under the trademark TERRAMAC® by the company UNITIKA.

In practice, the grid has a weight of between 10 and 50 g/m^2, advantageously in the order of 20 g/m^2.

According to a first embodiment of the invention, the grid is maintained on the whole surface of the support, at least on one or both of the faces according to preference, the grid being able to be placed facing either the soil or the sky. In this case, the mulching will be more particularly adapted to long growing of several months.

In a more economical second embodiment, the grid is placed exclusively in the area of fixing points of the support in the soil, that is to say in the area of air/ground/substrate interface. The Applicant has in fact noticed that the micro organisms in the soil degraded the support and had an important effect on its strength at the fixing points, making it especially sensitive to the weather, especially to the wind. The fitting of the grid in the area of these fixing points, on one or both of the support faces, thus allows slowing down its biodegradation at the points that are sensitive, yet without affecting this process, which is slower, on the part which is not buried.

In practice, the grid is glued directly against the surface of the finished fibrous support by means of a biodegradable water-resistant glue chosen from the group comprising ethylene polyvinylic alcohol (EVOH) and polyvinylic alcohol (PVA), by themselves or as a mixture. In practice, the glue represents between 5 and 50 %, advantageously 15 %, by weight of the grid.

Moreover and according to another characteristic, the support may be subjected to a lime sludge/ micrite coating step before or after gluing of the grid.

In a third embodiment, the grid is not glued but directly integrated into the mass of the support during the manufacturing process of the latter. Here again, the grid may be arranged over the whole surface of the support or exclusively in the area of the fixing points of the support on the ground. In practice, the grid is unrolled directly on the fibrous support during formation on the wire of the paper or non-woven machine, the grid in the finished product thus being entangled to the surface of the support. Furthermore, with this technique, glue is no longer needed.

In any case, the fibrous support may contain a hydrophobic resin representing 0,5 – 15%, advantageously 6 – 8%, by weight of the support, chosen from the group comprising urea-formaldehyde resins, melamine-formaldehyde resins, polyamide-amine-epichlorhydrin resins, polyethyleneimine resins, starch derivatives, by themselves or as a mixture.

Depending on the colour of the fibres used, the support may further comprise carbon black representing 0,5 - 4% by weight of the support.

In an advantageous embodiment, the fibrous support of the invention can be advantageously coated with an aqueous solution comprising 5 – 50% by weight of biodegradable natural latex obtained from the rubber tree, the balance to 100 % consisting of water, stabilizing and preservative agents of latex. The synthesis molecules such as bactericides (such as e.g carbendazine, isothiazoline), fungicides or

fungistats (such as e.g. potassium sorbate) can also be incorporated into the coating solution, even if for regulation reasons, these substances are to be more and more avoided.

Among the stabilizers are especially denoted, but in a non limitative manner, the substances chosen from the group comprising the vegetable proteins such as especially casein, soya protein, the fillers such as talc, calcium carbonate, by themselves or as a mixture.

In the list of the preservatives of latex, i.e. the agents able to avoid the degradation of the latex by the micro-organisms, appear especially the substances chosen from the group comprising the animal proteins such as glycerine, but also the tennins, especially that of mimosa, the natural colouring agent indigo, chitosan, by themselves or as a mixture. For allowing the fixation of tannin on the fibrous support, the coating solution contains metallic salts such as e.g. the aluminium sulphate $Al_2(SO_4)_3$.

In practice, the stabilizers represent from 1 to 50 % by weight of the coating solution. Also, the preservative agents represent from 1 to 30 % by weight of the coating solution.

According to another characteristic, the coating solution is coated in an amount of 10 to 200 g/m^2 as dry matter of latex, advantageously between 90 and 100 g/m^2.

In practice, the latex used is obtained from Hevea Brasiliensis and it has a dry rubber concentration at least of 60%. A latex corresponding to this definition is, for example, the one sold under the trademark ALCANTEX® by the company SAFIC-ALCAN.

Instead of natural latex, the fibrous support of the invention can be advantageously coated with an aqueous solution comprising 5 – 50% by weight of biodegradable prevulcanized natural latex obtained from the rubber tree. Prevulcanized natural latex is, for example, sold under the trademark REVULTEX MR® by the company SAFIC-ALCAN.

The prevulcanized natural latex can be made biodegradable by utilizing sulphur-eating bacteria, like sulfolobus acidocaldarius, for example by adding the bacteria with the prevulcanized natural latex fibrous support. Besides being biodegradable, the prevulcanized natural latex is easier to handle, for example a lifetime is longer if required.

In a particular embodiment, the coating solution consists, by weight, of:

- from 5 to 50%, advantageously from 15 to 25%, biodegradable natural latex obtained from the rubber tree,
- from 1 to 20%, advantageously from 5 to 10%, vegetable proteins,
- from 0 to 20%, advantageously from 5 to 10%, talc,
- from 0,1 to 1%, advantageously 0,5%, biocide,
- the balance to 100 part consisting of water.

In an advantageous embodiment, the biocides represent from 1 to 20 % by weight of the solution and are composed of chitosan and/or indigo, and/or glycerine, and/or tannin, by themselves or as a mixture.

When the grid is glued against the surface of the support, the coating of the support by the solution can be carried out before or after the fixing of the grid. In any case, whether the grid is incorporated during the manufacturing process or glued, the coated material obtained can be subjected to a lime sludge/ micrite coating step, that is to say to dry creping.

The thermobonding fibres distributed in the mass of the support, possibly in the presence of a grid and/or a coating based on latex from the rubber tree allows to maintain the mechanical resistance of the support during the whole growing period, yet without affecting the actual degradation process of plant fibres making up the said support. However, this actual degradation process of the support is directly dependent on its composition. In other words, the problem is how to define support compositions according to the desired growing periods.

Consequently and in a first embodiment, before the incorporation of biodegradable thermobonding fibres, the support fibre composition denoted hereinafter "support 1" is as follows:

- from 40 to 100%, advantageously from 70 to 90%, by weight of coniferous unbleached or bleached kraft fibres,
- from 0 to 60%, advantageously from 10 to 30%, of deciduous unbleached or bleached kraft fibres,
- grammage: from 40 to 200 g/m^2, advantageously 75 g/m^2.

This type of fibrous composition will be especially suitable for short growing periods from about 1 to 6 months.

In a second embodiment, before the incorporation of the biodegradable thermobonding fibres, the fibre support composition denoted hereinafter "support 2" is as follows:

- from 80 to 100% by weight of annual plant fibres,
- from 0 to 20%, advantageously from 5 to 15%, by weight of coniferous unbleached or bleached kraft fibres.
- grammage: from 40 to 200 g/m^2, advantageously 90 g/m^2.

The fibres from annual plants can come from all types of annual plants rich in fibres, which can be used in paper mills and in the filed of non-wovens e.g. of the cotton, ramie, jute, flax, hemp etc. type. In an advantageous embodiment, the fibrous composition contains only fibres that come from annual plants.

This type of composition will be especially suitable for longer growing periods from about 6 to 18 months.

In a third embodiment, before the incorporation of the biodegradable thermobonding fibres, the fibre support composition denoted hereinafter "support 3" is as follows:

- from 20 to 100% by weight of coniferous bleached kraft fibres, advantageously from red cedar wood-oil,
- from 0 to 40%, advantageously 20 – 30%, by weight of fibres from annual plants,
- from 0 to 40%, advantageously from 20 to 30%, by weight of rayon or viscose fibres.
- grammage: from 40 to 200 g/m^2, advantageously 100 g/m^2.

In practice, the supports are manufactured on a nonwoven machine, and then bond by mechanical and/or hydraulic needling. The support can also be manufactured by a carding process and then bound by mechanical and/or hydraulic needling process.

In an advantageous embodiment of the support 3, the fibrous composition further contains a very small amount of bactericide carbon fibres, that is to say carbon fibres doped with silver salts, in the order of 0,5 – 2% by weight.

This type of composition will be especially suitable for longer growing periods from about 18 to 36 months.

The invention and the advantages which stem therefrom will become more apparent from the following illustrative examples.

Example 1

A support with the following composition, by dry weight, was prepared:
- 73% of fibre suspension comprising 100% by weight of coniferous unbleached or bleached kraft fibres
- 20% of PLA-fibres, the average length of which is 5mm, sold by UNITIKA under the reference PL80
- 3% of epichlorhydrin resin
- 4% of carbon black
- grammage: 75 g/m^2

A sheet is formed on a paper machine from all constituents of the support. The support obtained this way is creped and then dried.

Example 2

The same procedure is repeated as for the support 1, with the exception that the fibre suspension contains 100% by weight of annual plant fibres (cotton, ramie, jute, flax, hemp). Grammage: 90 g/m^2.

Example 3

A support with the following composition, by dry weight, was produced:

- 73% of fibre suspension comprising:
  - 50% by weight of coniferous bleached kraft fibres, red cedar wood-oil
  - 25% by weight of annual plant fibres (cotton, ramie, jute, flax, hemp)
  - 25% by weight of rayon fibres
- 20% of PLA-fibres, the average length of which is 5 mm, sold by UNITIKA under the reference PL80
- 3% of epichlorhydrin resin
- 4% of carbon black
- grammage: 100 g/m^2

A sheet in formed on a paper machine from all constituents of the support. The sheet to be formed is subjected to a hydraulic entanglement step known by the name JETLACE. Next, the support is dried and then dry-creped/ coated with micrite.

Example 4

After the final drying stage, a grid of modified viscose sold by CHAVANOZ INDUSTRIE under the reference 4032/71 is glued in each of the examples 1 – 3, the glue representing 15% by weight in relation to the weight of the grid.

Example 5

Right after the drying steps carried out in the examples 1 – 4, the support is coated with a solution consisting (by weight) of:

- 50% natural latex sold under the trademark ALCANTEX® by the company SAFIC-ALCAN
- 5% proteins,
- 10% talc,
- 1% biocide,
- 34% water.

Finally, the coated support obtained is dried.